
II. *Obſervations upon the Spots that have been upon the* Sun, *from the Year* 1703 *to* 1711. *With a Letter of Mr.* Crabtrie, *in the Year* 1640. *upon the ſame Subject. By the Reverend Mr* William Derham, *F. R. S*

WHEN Spots on the Sun were more rare, than for theſe three or four Years laſt paſt they have been, this moſt Illuſtrious Society was pleaſed to accept of my Account of ſome of the firſt that for divers Years had been ſeen: Which for their Novelty were publiſhed, with ſome others, in the *Phil. Tranſact.* No. 288. But for as much as thoſe Obſervations of mine were imperfect, as I there confeſs'd, therefore to make ſome amends, I will give a better Account of the *Spots* and *Faculæ* that have been ſeen on the Sun ſince; there having, I ſuppoſe, few of thoſe Appearances eſcap'd my Sight, ſince their firſt being ſeen in 1703; and becauſe I am now better provided with competently good Inſtruments to take their Places on the Sun, *viz.* a *Micrometer* (after Mr. *Gaſcoign*'s manner) to take their diſtance from the Suns Northern or Southern Limb, which is parallel with the Pole of the Earth; and an *Half-Seconds Movement*, to meaſure their diſtance from the Suns Eaſtern or Weſtern Limb.

In this following Table, may be ſeen at one view, what *Spots* or *Faculæ* fell under my cognizance.

A Table of all the Spots *and* Faculæ *on the* Sun, *viſible at* Upminſter, *ſince* July 1703.

1703.	
Octob.	9
	10
	11
Nov.	19
	22
1704	
Jan.	16
	17
	18
	19
	21
	22
	23
Jan.	30
Feb.	23
	25
Mar.	7
	8
	9
	10
	11
	13
April	11
	12
	13
May	1
*	11
Jun. 23. none	
Some	24
Vaniſhed	25
July	18
	20
	21
*	23
Sept. *	10
nothing	14
	18
*	21
Nov	17
	18
	21
Dec. *	2
1705.	
Jan.	1
	2
	3
	5
*	25
Feb. *	19
March	14
	16
April	1
May	5
	6
	7
	8
*	10
	22
*	23
June	22
	23
	24
	26
	27
	28
	30
July *	1
*	3
	24
Sept.	30
Octob.	2
	3
	5
	6
	7
	25
	26
	30
	31
Nov.	2
	4
*	21
1706.	
Feb.	7
Mar.	7
	27
	30
April	2
Vaniſhed	3
June	7
	8
July	24
	25
Sept.	4
	5
	6
	7
	8
	10
Faint	11
Extinct	12
Oct. *	29
Nov.	5
Faint	6
*	8
	28
	29
	30
Dec.	1
	2
	3
	4
	5
	22
*	31
1707.	
Feb.	14
	15
	16
	18
	24
March	6
	9
	11
	12
	14
	18
	21
Jun. *	29
Extinct	30
July	1
Languid	2
Scarce viſible	4
More viſible	5
Extinct	6
Appears	8
*	10
Aug. *	31
Sept. *	12
	16
Spot &*	17
	19
	21
	27
No Spot nor *	28
Octob.	31
Nov.	1
	4
	8
	10
	15
	16
	17
	18
	19
	20
	22

N.B. *This* Nov. 15, *another Spot aroſe on the Eaſtern ſide of the Disk, whilſt this was on the Weſtern.*

In this Table the *Faculæ* are noted with an Aſteriſk; and the duration of every Appearance of the ſame Spots or *Faculæ*, or the time they diſappeared, with a Line: And where any thing remarkable occur'd, that could be briefly noted, I have taken notice of it in the Table.

There are many other things that I took notice of in viewing the Spots and *Faculæ*, which would be troubleſome to the Society, and indeed needleſs to particularly mention, ſince ſo many Accounts have been already given of them. But ſome things I ſhall ſelect, as may be of uſe to, and gratify ſuch as are curious in theſe Matters.

And firſt, as to the Figure of the Spots. They are well known to change frequently; and therefore I think it of little uſe to give their Figures every time I obſerv'd them. But it is ſomewhat remarkable, that the Spots generally appear longiſh near the extreme Parts of the Disk. If they are never ſo round near the middle of the Disk, they become longer and longer towards the Extremes, till (at going off) they ſeem to be nearly a ſtrait Line, nearly parallel to the Suns Limb. Which is a manifeſt Argument, that the Sun is a Globe, and that theſe Spots are on, or very near its Surface.

Another thing remarkable is, The Mutability of the Shape of the Spots. I have more than once manifeſtly perceived them to change in the very time I have been looking upon them. Thus *Nov.* 19. 1703. I ſaw three or more Spots not far off the middle of the Disk; and whilſt I was looking upon them, they ſeemed to vary, both as to their Shape and Strength; ſometimes ſeeming longer, ſometimes ſhorter; ſometimes ſpiſs, ſometimes languid. And this they ſeemed to do, not only through my 16 Feet Tube, (which I thought at firſt was from the different Diſpoſition of my Eye) but alſo when I received the Suns Image through a Six Feet Teleſcope,

leſcope, on a white Paper, in a darkened Room. Theſe mutable Spots the Weather hindred me from ſeeing again till *November* the 22d. following; and then they were become only like a thin Smoak, or *Nebula.*

So again *April* 11. 1704. there were divers Spots with *Umbræ* about them. Theſe *Umbræ*, or *Nebulæ*, I could plainly perceive, whilſt I was looking on them, to be ſometimes very faint and thin, and ſometimes much darker and thicker. Theſe *Maculæ* and *Umbræ* I obſerved ſuddenly brake out in the Sun: For, on *April* 9. the Disk was free. But this *April* 11. laſt mentioned, I perceived them advanced near a quarter part on the Disk: And conſequently they brake out in the Sun within 48 hours before. On *April* 13. the *Spots* were become *Umbræ*, in the Morning; and at Four of Clock in the Afternoon, there were no Remains of either *Maculæ* or *Umbræ*.

From this ſhort continuance of theſe Spots on the Sun, it is more than probable, they were in a perpetual Flux and Change; and that thoſe Mutations which I perceived in them, whilſt I was looking on them, were real, not imaginary.

Alſo it may be farther remarked, (which I have frequently obſerved, and which as I remember *Scheiner* obſerv'd long ago) That thoſe *Spots* and *Umbræ* which ſuddenly ariſe, do as ſuddenly decay, and are ſoon extinct. And ſuch Spots, I have farther obſerved, do ſeldom turn to *Faculæ*, as they commonly do when longer on the Sun, as I ſhall obſerve by and by.

Again, *May* 5. 1705. I could perceive two Spurs or Branches (running from a Spot) to change, and be ſometimes darker, ſometimes thinner.

So *March* 30. 1706. I obſerv'd ſuch another Variation. This Day, or but little before, *Spots* with *Faculæ* aroſe in the Sun, which remained not above three Days on him. One of theſe Spots I could manifeſtly perceive

ceive to be ſometimes quite extinct, and then again immediately to appear: And the *Faculæ* alſo, in half an hours time, had plainly alter'd their Shapes.

October 29. the ſame Year, I could plainly perceive the *Maculæ* and *Faculæ* both to change: And whilſt I was carefully viewing them, I ſaw a Spot ariſe in one of the brighteſt *Faculæ*, and again nearly diſappear; and then again appear ſtrong and ſpiſs. I ſhould have been glad to have ſeen how they appear'd next Day; but the Weather was Stormy, Cloudy, and Wet for ſeveral Days after.

Another thing I have obſerved (and not having the Book by me, I forget whether *Scheiner* obſerved the ſame or not) is, That the *Maculæ* do generally, if not always, become *Nebulæ* or *Umbræ* before they quite vaniſh; and after that, very frequently turn to *Faculæ*, or bright golden Spots, more illuſtrious and fulgid than the other Parts of that glorious Globe. If the Spots are of ſhort duration, *Faculæ* ſeldom enſue: Or if they do, they are commonly the Remains of ſome Spots that had before been on the Sun, and vaniſh'd perhaps on the ſide oppoſite to us. But Spots that long continue, if they vaniſh before that part of the Sun revolveth out of our ſight, do very often become *Faculæ*. Of which the Table affordeth ſeveral Inſtances, particularly *July* 3. 1705.

From theſe preceding Particulars, and their congruity to what we perceive in our own Globe, I cannot forbear to gather, *That the Spots on the Sun are cauſed by the Eruption of ſome new Vulcano therein*; which at firſt, pouring out a prodigious quantity of Smoak, and other opacous Matter, cauſeth the Spots: And as that fuliginous Matter decayeth and ſpendeth itſelf, and the Vulcano at laſt becomes more torrid and flaming, ſo the *Spots* decay and grow to *Umbræ*, and at laſt to *Faculæ*; which *Faculæ* I take to be no other than more flaming brighter Parts than any other Parts of the Sun. Theſe *Faculæ* I have obſerv'd never continue long on the Sun: And the reaſon I conceive is, becauſe the *Vulcano*, after its Smoak is over, doth not long emit its Flames; by reaſon the fiery *Pabulum* is then near ſpent, when once it begins to flame: After which the torrid *Vulcano* ſoon returneth to the Natural Temperature of the Sun, ſo nearly at leaſt as to eſcape our ſight, at ſo vaſt a diſtance as the Sun is from us.

Another thing that may be accounted for, and indeed doth in ſome meaſure confirm alſo what I have ſaid, is the *Nuclei*, or darker part of the Spots; generally in moſt Spots, and towards the middle of them. Now it is very uſual in Culinary Fires in this our Globe, when they emit Smoak, that the middle is the darkeſt part. If, for Inſtance, we were from aloft in the Air, to ſee a thick Smoak come tumbling out of a *Chimney*, or the Mouth of a *Vulcano* juſt kindled, we ſhould find the middle part, juſt over the Mouth of the *Chimney*, or *Vulcano*, to be the moſt ſpiſs and dark, and towards the extremes clearer and thinner. And ſo I take it to be in the Eruptions of the Sun; that the *Nucleus* is juſt over the Mouth of the ignivomous Cavern, and that the miſty Parts of the Spot are the thinner Parts of the Smoak, ſwimming about in that Fluid, or *Atmoſphere*, which I ſuppoſe doth ſurround the Sun, as well as our Globe, and the Moon manifeſtly; yea, and in all probability, every Planet of this our Solar Syſtem.

From what hath been ſaid, we may give a reaſon why there are ſometimes Spots frequently on the Sun, and ſometimes none in many Years. One thing I believe there is in this, That there may be Spots, but not always ſeen. But there are doubtleſs great Intervals ſometimes when the Sun is free; as between the Years 1660 and 1671, 1676 and 1684. In which time Spots could hardly eſcape the ſight of ſo many curious Obſervers of the Sun, as were then perpetually peeping upon him with their Teleſcopes in *England*, *France*, *Germany*, *Italy*, and all the World over; whatever might be before, from *Scheiner*'s time. The reaſon, I ſay, of this long diſappearance of the Spots, I take to be from the want of extraordinary Eruptions in that fiery Globe. The Sulphureous, or other Matter, or *Pabulum* of thoſe Eruptions, is ſpent or diſſipated, and that Globe continues in its natural ordinary burning State, till there happens to be a freſh Collection of Smoaking, Diſploſive, and extraordinary Matter, that cauſeth a new Eruption. Which Eruptions generally happen between what we may call the Suns Tropicks, or in his Torrid Zone: For I never obſerv'd any Spots to be near the Suns Poles. And if I miſremember not, the Spots in *Scheiner*'s Cuts are all about the middle Zone of the Disk. The greateſt Evagation I ever obſerved of them was *March* 8. 170¾. On which Day, beſides the dark Spots in the uſual Zone, I perceived ſome faint Spots, ſcarce viſible, much nearer the Southern Pole than I ever had ſeen them. But this was, no doubt, in ſome meaſure owing to the Poſition of the Earth in reſpect of the Sun, as well as to the Southerly Place of the Spots on him: For, about the Equinoxes, the Spots ſeem to march pretty far towards the Poles of the Sun, as may be ſeen by the annexed Schemes. (*Tab.* II.)

Having thus obſerv'd what part of the Sun the Spots commonly poſſeſs, I ſhall next take notice of their *Stages* and *Path* over the Sun. That the Sun moveth round his own *Axis*, is manifeſt, beyond doubt, from the Motion of the Spots. And that the Spots ſeem to traverſe the Sun, ſometimes in Strait Lines, ſometimes in Curve Lines, curved this way, and that way, is as manifeſt alſo, and well known to the Curious, and is ſet forth in the annexed two Figures; Which Figures ſhew the Stages of the Spots every Day that I obſerv'd them, and the Lines they deſcribe in ſeveral Months of the Year. The daily Stages in both Figures are exact; or if they ſeem otherwiſe, it is by reaſon the Obſervations were made at different times of the Day; as one in the Morning, the other ſome following Day in the Evening, or Afternoon. But the Declinations of the Spots, or their diſtances from the Suns Northern or Southern Limb, are leſs exact in the ſecond Figure than the firſt; in which latter they are very near the truth.

And the Cauſes of the Defects in the 2d Scheme I ſhall mention, to prevent the ſame Errors in others I my ſelf ran into.

1. The Diminution of the Suns vertical Diameter by the Refractions was the principal cauſe of my Errors. This, altho' I was ſufficiently aware of, yet I did not think had been ſo conſiderable, for want of experimenting, or well conſidering the Matter: For I have ſometimes found the perpendicular, or vertical Diameter of the Sun diminiſhed, from 32′ 21″ on the Meridian, to 26′ 3″ at the Horizon, in one and the ſame Day.

2. For the ſame reaſon I was not aware of the time being ſo long before the Sun goes round, as I found it.

3. Another Error was meaſuring the Suns Image on the Scene of white Paper, with the Shade of the Micrometer; and not by looking through the Tube, and ſo claſping the Limb of the Disk with the parallel edges of the Micrometer. The former, altho' practiſed by ſome eminent Aſtronomers, is a far more eaſy and indulgent, than accurate way.

A further Account of the Solar Spots to the Year 1711.

SINCE my foregoing Account was drawn up, I have ſeen other Spots on the Sun, whoſe times are expreſſed in this following Table.

1707.		1709.	
Decemb.	4	*Jan.*	15
	10		21
	* 29		22
	* 30	*Auguſt*	13
			* 17
1708		*Octob.*	8
July	31	*Novemb.*	1
Auguſt	1		2
	5		4
	6		5
	22		6
	23		
	24	1710.	
	28	*Jan.*	22
Septemb.	1	*April*	* 6
Novemb.	5	*Octob.*	14
Dec.	14		* 18
	26		

From the Spots in this Table I had frequent occaſions to be aſſured of my Opinion, in the foregoing Paper. Particularly in viewing the Spots of *Auguſt* 1. 1708. (repreſented in *Tab.* II. *Fig.* 3.) where ſome were large and dark, others leſs and thinner, and all encompaſs'd with *Nebulæ*: In viewing theſe, I ſay, I obſerv'd great alterations at the very time I was looking on them. Sometimes the *Nuclei* were very dark and black, ſometimes leſs ſo; and the ſame thing I obſerved alſo in the *Nebulæ* encompaſſing them. One of the leſſer Spots *b.* in *Fig.* 3. which the Day before was ſufficiently viſible and ſtrong, was this Day, now thick and ſtrong, and anon languid and leſs viſible. And from the two Spots *a.* and *d.* I could plainly ſee a Smoak iſſuing out to *c.* and *f.* ſometimes viſible for 5 or 6 Minutes, and then diſappearing for a quarter of an Hour, or more; and then again ſmoaking out, and again diſappearing, as before. All which Particulars, I ſaw over and over again repeated, for a good while together, till I was weary of the Obſervation.

Theſe Spots I was hindered from viewing until *Aug.* 5. following: And then I found the Spot *b.* quite extinct, (as I expected,) as alſo ſome of the other Spots; together with the *Nebulæ* grown leſs. But the great Spot *a.* continued dark and ſtrong, only ſometimes fainter, and then again ſtronger; and ſometimes like a half, or horned Moon; ſometimes roundiſh, or rather of an Oval Figure; of which latter Figure they commonly are, when they are near the Suns Limb, which this Spot was not far off at this time.

Theſe particulars are Confirmations of what I ſaid, *That the Solar-Spots are no other than a Smoak riſing out of the body of the Sun.* Of which Opinion I have been almoſt ever ſince I firſt obſerv'd them, and find that I am not ſingular in this Opinion, as I ſhall ſhew from a Letter (which with ſome others is lately fallen into my Hands) from the admirable Mr. *Crabtrie* to the no leſs admirable Mr. *Gaſcoigne*, the Inventor of the Micrometer; which I preſume will hardly be ungrately to this moſt illuſtrious Society.

The beginning of the Letter hath been torn off; but I find by that part of it that is left, it was Mr. *Crabtrie's* firſt Letter to Mr. *Gaſcoigne*, and that the torn part was only Compliments for his Writing to him, being a Stranger, *&c.* After which it follows in theſe Words.

“ I writ alſo to Mr. *Townley* at that time my Opinion
“ in brief of the Suns Spots, (which you conceive to be
“ Stars,) and it ſeems he, or Mr. *Kay*, writ to the ſame
“ purpoſe to you, deſiring your Opinion: Which you
“ freely deliver; for which I cannot but commend you,
“ and eſpecially for prefering Reaſon before any Mans
“ Authority. Yet give me leave (*pace tua Amice deſide-*
“ *ratiſſime*) to ſpeak my mind likewiſe freely concerning
“ theſe Appearances. I do not value the Authority
“ of *Galilæus* (though reputed the greateſt Speculative
“ Mathematician in *Europe*) nor yet *Kepler* (though
“ *Aſtronomorum facilè princeps*) further than either De-
“ monſtrative, or the moſt probable Reaſons confirm
“ their Opinions. Nor will I ſtick to ſubſcribe to the
“ Man whoſoever ſhall bring better Reaſons for his O-
“ pinion. I muſt acknowledge you ſay more for the
“ ſtellifying of theſe Solar Obſcurities, than I have heard
“ before; yet I conceive not ſufficient, either demon-
“ ſtratively or probably to countermand thoſe which
“ *Galilæus*, *Kepler*, and others have produced to the
“ contrary; nor yet ſuch as can be cleared from ſuch
“ Objections, as Reaſon, Demonſtration, and Obſerva-
“ tion may lay againſt them. My Occaſions will not
“ admit a full Diſquiſition hereof at this time; yet
“ ſomething I would ſay for the preſent, the better to
“ furniſh you where to object when I ſee you; that
“ ſo by diligent Inquiſition, the deſired truth may
“ (may we have that happineſs) be better found out
“ by us.

"I have often obſerved theſe Spots; yet from all my Obſervations cannot find one Argument to prove them other than fading Bodies. But that they are no Stars, but unconſtant (in regard of their Generation) and irregular Excreſcences ariſing out of, or proceeding from the Suns Body, many things ſeem to me to make it more than probable.

"For firſt, for their Form; they are ſeldom round, but of irregular Shapes, and, as I have often ſeen, one ſide, or end of the Spot more thin than the reſt, like to a certain miſty darkneſs, and by degrees thicker, groſſer, and darker, nearer to the main body of the Spot; juſt as the Smoak of ſome pitchy Fire, which is in one part very groſs, and in another more rare and thin, turning at laſt into meer Air: Or like a Cloud, Fog, or Miſt, more thick, dark, and groſs in the midſt; and more thin, fluid, penetrable, and tranſparent towards the ſides; which I ſuppoſe is not compatible with any of the Stars.

"Secondly, for their Colour: The lighneſs thereof differenceth them from Stars, or Planets; they being never of ſuch abſolute darkneſs as I obſerved *Venus* the 24th of *November* laſt: Tho' I have ſeen ſpots ſometimes little leſs than ſhe, yet always of a far paler and whiter Colour, looking (at leaſt in ſome Parts) like ſome thin diſſipated ſubſtance.

"Thirdly, for the manner of their appearance. I have ſeen many Spots, which in the middle of the Sun appear of a round body, but coming towards the ſide of the Sun, appear long. Which (if you rightly conſider it) is a demonſtrative Argument that they are not Globes, as all the Planets and Stars are: For Globes always appear of one form (round) in every Poſition; but Exhalations, or ſuch like fluid Subſtances, extended to a broad flat form, like our Clouds, which being over our Heads, and ſo in their full

" breadth, appear large and broad; but driven with
" the Wind, till they turn one edge upon us, ſeem of
" a long ſhape. So theſe Solar-Clouds, being turned
" about the Sun, may in the middle ſhew their full
" breadth to us, and about both edges of the Sun, turn
" their edges to us: Which anſwereth to the appearance.

" Fourthly, for their continuance. Some of theſe
" Spots, ariſing at the Eaſt-ſide of the Sun, vaniſh before
" they come to the midſt of the Sun. Others appear
" firſt in the middle of the Sun, and vaniſh before
" they come to the Weſtern Limb; and for the moſt
" part they vaniſh before they have made a full revolution
" about the Sun. Which argues them to be but
" thin, vaniſhing, fading Subſtances, not like the permanent
" bodies of the Stars.

" But to take off theſe Reaſons, you anſwer, That
" you conceive theſe Spots to be Stars moving regularly
" in their own Orbes, which are many, though none of
" greater extent than about $\frac{1}{10}$ of the ⊙ Semidiameter
" from its Circumference; and that the ſwifter Movers
" in the lower Orbes, overtaking the ſlower in the
" higher Orbes, cauſe an appearance. You ſeem therefore
" to think, that they being ſo thin bodies, the
" Suns Rayes paſs through them, and ſo one cannot
" be ſeen alone, till more being together, one heaped
" behind another, they ſtop the light of the Suns Rayes,
" and ſo cauſe an appearance. This I conceive is you
" meaning: Or elſe (as you ſeem to inſinuate afterwards)
" that the Higher reflects the Suns Rayes ſtrongly enough
" upon the Lower (when they come within the
" Angle of Reflection) to make the interjacent Planet
" indiſcernable.

" But to theſe I anſwer,

1. " If it be by their coming within the Angle of
" Reflection, that the light of the Sun reflected from
" the

“the outer Planet upon the inner, doth make it (as you ſpeak) indiſcernable, then that Light ſo reflected is reflected either upon all places, as the Moons and Planets Light; or but upon one, as is the Reflection of a plain Looking-Glaſs. If the firſt, there would never be many ſeen (ſeldom above one or two) becauſe the outermoſt would continually make the inner undiſcernable. But *Gaſſendus* affirms, there are ſeen ſometimes 40 at once in the Suns body. If the 2d, there would always be many ſeen, becauſe the reflected Light would but occupy a little room, and that but for a ſmall time, till the ſwifter were paſt the place of Reflection: Whereas many Days there are none at all ſeen in the Suns Hemiſphere: And in both theſe caſes, the outermoſt Planet of all would always in the ſpace of 27 Days, be ſeen in the ſame place, being never obſcured, none of the inferior being able to reflect Light upon it. Add hereunto, if any kind of Reflection ſhould make them to appear bright like the Sun, and ſo not diſtinguiſhable from the Light of the Sun, what ſhould (*a*) hinder, but we ſhould ſee them alſo bright Bodies by the ſide of the Sun, when they are paſſing either by the Weſt, or Eaſt-ſide of the Suns Body? The Light being then reflected upon them by the inferior Planets as well as at other times, and that alſo upon much of that ſide of them which we ſhould behold.

(*a*) N. B. *Mr* Gaſcoigne *having, againſt theſe Words, inſerted a rough-drawn Figure in the Margin of Mr* Crabtrie's *Letter, I have alſo repreſented it in* Tab. 2. Fig. 4. *imagining it may ſomewhat explain Mr* Gaſcoigne's *Hypotheſis, and what Mr.* Crabtrie *ſaith againſt it.*

“ But if you wave this conceit, as inſufficient, and fly
“ to your former, That the ſwifter Movers in the
“ lower Orbes, overtaking the ſlower in the higher
“ Orbes, cauſe an appearance. To this I anſwer.
“ 1. The thing you ſuppoſe ſeems to me neither ne-
“ ceſſary nor probable, nor do I conceive why they
“ ſhould not be ſeen, being themſelves alone, as well as
“ conjoined, ſeeing all other Stars and Planets are ſo.
“ 2. If it be becauſe they are of a thin, tranſparent
“ Subſtance, till many, being one behind another, make
“ them to ſeem groſſer; Then they are not of the
“ nature of other Planets, as is proved in ☿ and ♀,
“ who of themſelves appear dark Bodies, when they
“ come between us and the Sun; nay, they muſt be
“ more thin than our Clouds, which will eaſily be ſeen
“ between us and the Sun, and hides it from us. 3. If
“ it be becauſe they are ſo little, that the Imperfection
“ of our Glaſſes cannot diſcover one alone, there muſt
“ be, without doubt, many Millions of them; which
“ how they can be included within the compaſs of $\frac{1}{10}$
“ of the ⊙ Semidiameter, we ſhall conſider anon. I
“ have ſeen one of an ordinary darkneſs, (yea darker
“ than many greater) yet not above $5''$ Diameter. If
“ this conſiſt of two, or many, of themſelves inviſible,
“ how many were in thoſe which *Gaſſendus* ſaw of $1'\frac{1}{2}$
“ Diameter? 4. The Figure of theſe great ones (being
“ neceſſarily compoſed of Stars of ſuch different Orbes
“ and Motions) would quickly vary, by reaſon of the
“ diverſity of their Motions; like as we ſee in a Flock
“ of ſmall Birds. But 5thly, you ſay the furtheſt of
“ theſe Orbes is not above $\frac{1}{10}$ of the Suns Semidiameter
“ from its Circumference. But there would not, in that
“ ſmall ſpace, be room enough for ſo many Orbes of
“ Planets, as have been ſeen at once. Which I prove
“ thus. 1. *Gaſſendus* affirms there are ſometimes ſome
“ of about the $\frac{1}{10}$ part of the ⊙ Semidiameter; which
“ is

“ the whole ſpace allowed by you for them all. And
“ I my ſelf have ſeen of $\frac{1}{15}$ of the ⊙ Semidiameter: And
“ yet you muſt confeſs theſe great ones could only be
“ the Conjunctions of ſome, not all. 2. There are
“ many times ſeen in the ⊙ Superficies, a great number
“ of Spots, whoſe Diameters added together, would
“ do more than twice fill the ſpace you ſpeak of. I my
“ ſelf have ſeen it, and ſo I believe have you. *Gaſſendus*
“ affirms, there are ſometimes 40 ſeen at once:
“ If this was by Conjunction of Planets, in every Appearance,
“ there was at leaſt 80 Bodies at once on this
“ ſide the ⊙; it may be as many on the other ſide,
“ beſides thoſe unſeen (by your Reflection or otherwiſe)
“ which doubtleſs muſt be far more than ſeen.
“ For it is a moſt rare, and I think unheard of thing
“ to ſee but 3 (which is leſs than the half) of our
“ Planets, conjoin'd in viſible ☌ at once: So that without
“ queſtion, if they be Planets, they are many hundreds;
“ which muſt have ſo many ſeveral Orbes, and
“ which certainly cannot be done in ſo narrow a compaſs,
“ as the $\frac{1}{10}$ of the ⊙ Semidiameter. And that
“ they cannot have any larger (I ſuppoſe not ſo large
“ an) extent from the ⊙ Superficies, may be proved by
“ their motion through the viſible Hemiſphere of the
“ Suns Spherical Body, by comparing the ſwiftneſs of
“ their motion towards the middle and ſides together.
“ 6. If one of theſe (imagined) Planets be ſwifter than
“ another, as they muſt needs be, then the ☌ of 2 or
“ 3 ſwifter ones would make a Spot of ſpeedier motion
“ than the ☌ of 2 ſlower ones: But the motion of all
“ about the ⊙ Center, is always equal; yea, and the
“ Spots retain the ſame Poſition one to another, (conſidering
“ the Suns Sphericity, and the Angle of their
“ appearance to us) juſt like the Fixed-Stars. So affirms
“ *Gaſſendus, Moveri omnes eodem & uniformi motu, adeo*
“ *ut, cum plures fuerint, nulla antevertat aliam, ſed eun-*

“ *dem tenorem in diſco* ☉ *perinde ſervent inter ſe, ac ſervant Fixæ in firmamento.*

“ As for that other annual Motion of the Spots, you ſpeak of, from Weſt to Eaſt, upon their Axis inclined above 8 Degrees to the Eclíptick; I ſuppoſe it is not any real Motion of the Orbes of thoſe Solar Planets or Spots, but only a viſible Motion ſo appearing, cauſed (in *Kepler*'s Syſteme) by the Suns rolling upon its own Center in the midſt of all the Orbes, not exactly in the way of the *Temporary* Ecliptick, but in the *Via regia* (as *Kepler* calls it) inclined certain Degrees to the *Temporary*; thereby turning about with him, the ſame way, his Adventitious, or Excrementitious Parts, the Spots, by his *Magnetical* or *Sympathetical Rayes.* And hence may be demonſtrated the appearance of that Annual Motion in the Suns Spots you ſpeak of. See *Galilæus, Syſt. Coſm. p.* 339, *&* *ſeq.* So alſo in *Ptolemie*'s and *Tycho*'s Syſteme, the ſame Appearance may be demonſtrated, ſuppoſing the ⊖ fixed in the middle of the Univerſe, and the ☉ rolling round upon the ſame Poles of that *Via regia* (or way of the Spots) and keeping his Axis in Paralleliſm continually towards one and the ſame Part of the Univerſe. This may be certainly demonſtrated, altho' *Galilæus* there affirms the contrary. Other *Hypotheſes* of that Motion may be feigned, as by the annual converſion of the Poles of the *Via regia* about the Poles of the Ecliptick in the Suns Body: But none I conceive ſo compendious, as the one of the former. For my part, I incline to the firſt: Yet if when we ſee you, you ſhew us any more likely Theory, for my part I ſhall be ready to conſent to you in any thing with reaſon.

“ Thus you have, what for the preſent, I conceive of theſe *Maculæ Solares. Fromundus* mentions one *Jo. Tarde Gallus*, who thinks them to be Secondary

“ Planets; who hath written a Book of that Subject, and calls them *Aſtra Borbonia* : But I could never yet ſee it. What you, or he, or others may alledge for that Opinion, I know not. In the mean time it were too much levity in me, againſt my Judgment, to acknowledge them Stars; unleſs I ſee at leaſt ſome poſſibility how they may be ſo, or ſome probability why they ſhould not rather be Spots. Which when you, or they do produce from better grounded Reaſons, Optical Experiments, or Demonſtrations, I ſhall willingly recant my Opinion.

“ In the mean time, let me encourage you to proceed in your noble Optical Speculations. I do believe there are as rare Inventions as *Galilæus Teleſcope*, yet undiſcover'd. My living in a place void of apt Materials for that purpoſe, makes me almoſt Ignorant in thoſe Secrets; only what I have from Reaſon, or the reading of *Kepler's Aſtron. Opt.* and *Galilæus*. If you impart unto us any of your Optical Secrets, we ſhall be thankful, and obliged to you, and ready to requite you in any thing we can.

“ It is true which you ſay, That I found *Venus* Diameter much leſs than any Theory extant made it. *Kepler* came neareſt, yet makes her Diameter 5 times too much. *Tycho*, *Lansberge*, and the Ancients, about 10 times greater than it was. So alſo they differ in the time of the ☌ as far from the truth. By *Lansberg* the ☌ ſhould have been 16^h $31'$ before we obſerv'd it: By *Tycho* and *Longomontane* 1^d 8^h $25'$ before. By *Kepler* (who is ſtill neareſt the truth) 9^h $46'$ before. So that had not our own Obſervations, and Study, taught us a better Theory than any of theſe, we had never attended at that time for that *rare Spectacle*. You ſhall have the Obſervation of it, when we ſee you. The Clouds depriv'd me of part

“ of the Obſervation, but my Friend and ſecond Self
“ Mr. *Jeremiah Horrox*, being near *Preſton*, obſerved it
“ clearly from the time of its coming into the Sun,
“ till the Sun's ſetting; and both our Obſervations agreed,
“ both in the Time and Diameter, moſt preciſely.
“ If I can, I will bring him along with Mr. *Towneley*
“ and my ſelf, to ſee *Yorkſhire*, and you. You ſhall
“ alſo then have my Obſervation of the Sun's laſt Eclipſe
“ here in *Broughton*, Mr. *Horrox*'s between *Liverpoole*
“ and *Preſton*, and Mr. *Foſter*'s at *London*. *Langsberg*
“ in Eclipſes, eſpecially of the ☽, comes often
“ nearer the truth than *Kepler*, yet it is by packing
“ together Errors; his Diameters of the ⊙ and ☽ being
“ falſe, and his variation of the Shadow being
“ quite repugnant to Geometrical Demonſtration. His
“ circular Hypotheſes Mr. *Horrox* (before I could perſwade
“ him) aſſayed a long time with indefatigable
“ Pains, and Study, to correct, and amend; changing
“ and turning them every way (ſtill amazed and amuſed
“ with thoſe lofty Titles of Perpetuity and Perfection,
“ ſo impudently impos'd upon them) until we found,
“ by comparing Obſervations in ſeveral places of the
“ Orbes, that his Hypotheſes would never agree with
“ the Heavens for all times, as he confidently boaſts;
“ no, nor ſcarce for any one whole Year together, alter
“ the equal Motion, Proſthaphæreſes, and Excentricity
“ howſoever you will.

“ *Kepler's Elliptick* is undoubtedly the way which
“ the Planets deſcribe in their Motions: And if you
“ have read his *Comment. de motu* ♂^{is}, and his *Epit.*
“ *Aſtron. Copern.* I doubt not you will ſay his
“ Theory is the moſt rational, demonſtrative, harmonious,
“ ſimple, and natural that is yet thought of,
“ (or I ſuppoſe can be;) all thoſe ſuperfluous Fictions
“ being rejected by him, which others are forced ſo
“ abſurdly to introduce. And although in ſome reſpects

" his Tables be deficient, yet being once corrected by " due Obſervations, they hold true in the reſt: Which " is that argument of Truth, which *Lansberge*'s and all " others want.

" Your conceit of turning the Circle into 100,000,000 " Parts, were an excellent one, if it had been ſet on " foot, when Aſtronomy was firſt invented. Mr. *Horrox* and I have often conferred about it. But in re-" ſpect that all Aſtronomy is already in a quite diffe-" rent form, and the tedioufneſs of reducing the Ta-" bles of Sines, Tangents, and all other things we " ſhould have occaſion to uſe, into that form; as alſo " ſome Inconveniences which we foreſaw would follow " in the compoſing the Tables of Celeſtial Motions, " together with the greatneſs of the Innovation, de-" terred us from the conceit. Only we intend to uſe " the Centeſmes or Milleſmes of Degrees, becauſe of " the eaſe in Calculation. I have turned the *Rudolphine*-Tables into Degrees and Milleſmes, and altered " them into a far more conciſe, ready, and eaſy form, " than they are done by *Kepler*. My Occaſions force " me to put an abrupt End to my unpoliſh'd Lines, " and without more Compliments, to tell you plainly, " but ſincerely, I am

Your Loving Friend,

From my Houſe in
Broughton *near*
Mancheſter, *this*
7. *Auguſt* 1640.

(*though* de facie ignotus)

WILLIAM CRABTRIE.

The Superſcription of this Letter is, *To his Loving Friend Mr.* William Gaſcoigne, *at his Fathers Houſe in or near* Leeds *in* Yorkſhire.

This with moſt of the Letters between Mr. *Crabtrie* and Mr. *Gaſcoigne*, together with other very valuable Papers of Mr. *Horrox*, Mr. *Towneley* himſelf, Mr. *Collins*, Mr. *Shuſe*, and other great Men, were imparted unto me, the laſt Month, by the great favour of *Charles Towneley* Eſq; Son of the late moſt Ingenious *Rich. Townley* Eſq; of *Lancaſhire*.

And foraſmuch as every thing of Mr. *Crabtrie*'s is valuable, I have taken this occaſion from my own Obſervations of the Solar Spots (for the moſt part drawn up near 4 Years ago) to give Mr. *Crabtrie*'s Letter at large, containing as well ſome things of another Nature, as what relates to the Spots; not doubting but the one will be acceptable to the Curious, as well as the other. I have two other of his Letters concerning the Spots (with Mr. *Gaſcoigne*'s Anſwers.) One contains his Theory of their Motion and Appearances; the other his way of obſerving them. But being long, I have not time at preſent to fit them up for the Societies Uſe; but intend (God willing) to do it as ſoon as may be, if this Specimen be acceptable.

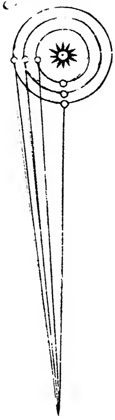
N. B. Tab. II. Fig. I. *Shows the Stages and Lines deſcribed by the Spots upon the Sun in* Sept. *and* Novemb. 1706. *and in* Feb. *and* March, $170\frac{6}{7}$. *and in* Sept. *and* Novemb. 1707.

Fig. II. *Shows the Stages and Lines deſcribed by the Spots upon the Sun in* Jan. $170\frac{3}{4}$. *and in* May, June, *and* Octob. 1705.

The other Figures *in this* Table *are explained in the foregoing Diſcourſe*.

Tab. II.

Fig: 4.



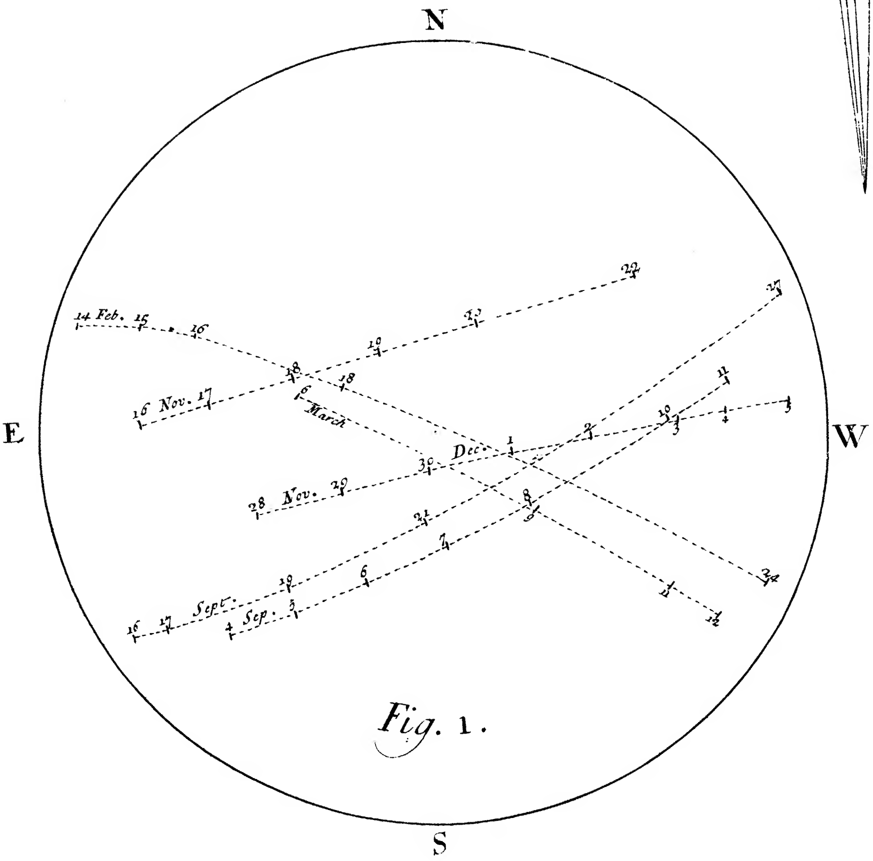


Fig. 1.

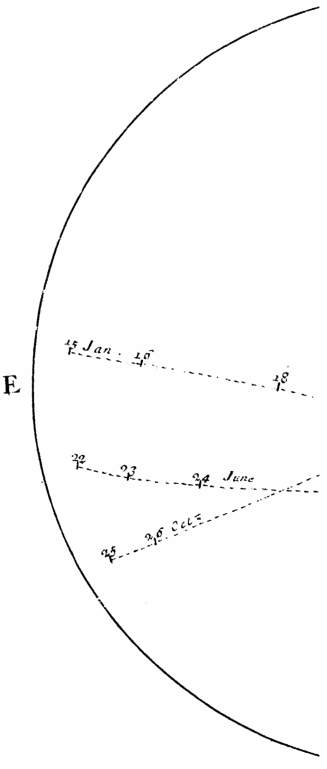
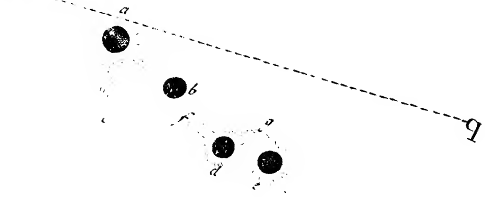


Fig: 3.



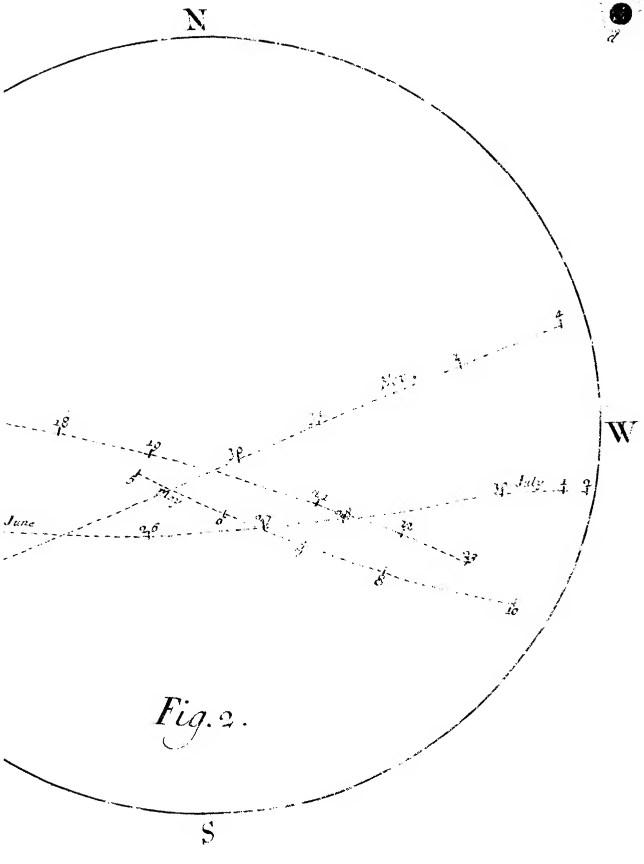


Fig. 2.

Fig. 4.

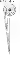


Fig. 3.

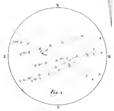


Fig. 1

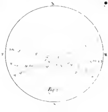


Fig. 2